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PROVISIONAL SPECIFICATION

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Invention Title: **Fasteners**

The following statement is a description of this invention

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This invention relates to fasteners. The fasteners may be particularly suitable for use in connection with automobiles and the description below will generally focus on this application. However, it is to be understood that the scope of the invention is not limited to this application.

There is a marked trend towards increasing electronic control in motor vehicles. Nowadays, many motor vehicles incorporate computer systems which use a Controller Area Network (CAN) in which modules communicate data to the computer via a bus, or a local interconnect network (LIN) which also enables communication of data via a bus.

The present invention in its many aspects is intended to take advantage of the trend towards increased electronic control in vehicles. The present invention provides several versions of fasteners which may be suitable for use in vehicles and which may provide significant advantages in relation to assembly of vehicles and service of vehicles. In particular, the fasteners of the present invention may be suitable for connection to a vehicle computer via a CAN or LIN.

In a first aspect, this invention provides a releaseable fastening system including a pin adapted to be received in an aperture, the system including means associated with the aperture for locking or unlocking the pin, the means including a material adapted to contract when activated to unlock the pin.

The pin may be chosen from a large range of suitable shapes. As one example, the pin may be generally circular in cross-section, tapering in from a flanged base and having a further taper in at the end remote from the flanged base. In this example, the pin may include a groove around its circumference. The groove may be adapted to receive a locking means or a plurality of locking means around the circumference of the groove. In this embodiment, the locking means may have a latch engaged in the groove when the pin is locked and adapted to be moved out of engagement with the groove, and so unlock the pin, by a shape memory alloy wire which contracts when heated.

In another embodiment, the pin may be bifurcated, being bisected for part of its length by a passage which, at its base, forms a twisted channel, similar to a quarter turn type clip. In this embodiment, the locking means may include a shape memory alloy wire which extends from one side of the aperture to the other. The pin can be pushed through the aperture so that the wire is seated in the twisted channel, the wire deforming to follow the twist of the channel. The twisted channel has an undercut at each end to prevent the wire from unclipping and so the pin is locked to the aperture. Heating of the shape memory alloy wire causes it to straighten, so that it no longer follows the twisted channel. In this embodiment, it is preferred that a compression spring urges the pin away from the aperture, so that, on contraction of the wire, the pin and the aperture part company.

Other embodiments of the pin and the locking means are within the scope of the invention.

The material adapted to contract when activated is preferably shape memory alloy wire, as described in connection with the two embodiments above. Shape memory alloys are known and are usually made predominantly or wholly of titanium and nickel. They may also include other material, such as aluminium, zinc and copper. A shape memory alloy is capable of adopting one shape below a predetermined transition temperature and changing to a second shape once its temperature exceeds the transition temperature. Conversely, when the shape memory alloy cools below the transition temperature, it is capable of adopting the first shape again. In connection with the various aspects of the present invention, it is preferred that the shape memory alloy contracts (or straightens, as appropriate) when heated in situ.

The scope of the invention in its various aspects is not necessarily limited to the use of shape memory alloy. Other material may also be useful.

The pin in this first aspect of the invention may be formed integrally with or attached to an element to be fastened. The aperture may be formed in a second element to be fastened to the first or in a washer, for example, attachable to the second element in a

suitable manner. In both the case of the pin and the case of the washer or the like, attachment may be by adhesion, clipping or other suitable means.

The fastening system of this first aspect of the invention may be particularly suitable for fastening interior panels in automobiles. One example is the fastening of the interior lining of a door panel to the car door.

The function of the fastening system of the invention described above may be regarded as a primary function. The fastening system may have a secondary function, according to which the fastening system controls simple component switching. One example of this is the control of a window motor in a car door. In this context, the releaseable fastening system is not used to connect one element, such as the interior lining of a car door, to a second element, such as the car door itself. Instead, the releaseable fastening system is used to act as a switch in connection with the operation of, for example, a window motor, a door lock assembly, headlights and so on.

In connection with the first aspect of the present invention, the invention also provides a method of releasing a pin from engagement with a locking means associated with an aperture in which the pin is received, the means including a material adapted to contract when activated, the method including the step of activating the material to contract it.

In a second aspect, this invention provides a releaseable fastening system including:

a first member;

a second member having at least a portion adapted for receipt in at least a portion of the first member;

means moveable between a first position in which the received portion of the second member is pressed outwardly against the receiving portion of the first member, and a second position in which the received portion of the second member is not pressed outwardly against the receiving portion of the first member;

means for drawing the received portion of the second member out of contact with the receiving portion of the first member; and

means for drawing the moveable means from the first position to the second position, the drawing means including a material adapted to contract when activated.

The releaseable fastening system in the second aspect of the invention is intended to permit locking of the system by hand and unlocking by activation of the contractible material. A non-limiting example of application of the fastening system of this second aspect of the invention is a fastener for an automobile spare tyre. A preferred embodiment will be described in connection with this application but it is to be appreciated that this does not limit the scope of the invention.

In the preferred embodiment, the spare tyre on the wheel hub is connected to the vehicle by a type of bolt having a hollow shaft. The head of the bolt may be decorative, especially if the spare tyre is on display attached to the rear of the vehicle, such as in the case of a four wheel drive, or other "off road" recreational vehicle. The hollow shaft of the bolt may represent either the first member or the second member of the fastening system of the invention. For ease of description, the hollow shaft of the bolt will be described as the first member. In this embodiment, the second member is a hollow shaft with a certain amount of flexibility.

Each of the first and second members, in this embodiment, has an engagement surface at or near the open end of the shaft. The engagement surface conveniently consists of a screw thread, in this embodiment located on the internal surface of the first member and the external surface of the second member.

The moveable means is moveable within the second member. It is biased by a spring or other suitable means towards the open end of the second member, in which position the moveable means is able to maintain contact with the sides of the second member so that the engaging surface of the second member firmly engages the engaging surface of the first member. Preferably, the first member can be rotated to be secured to the second member but cannot be unscrewed, a ratchet or pawl being provided for this purpose. In this position, the first member is locked to the second member.

The material which contracts when activated is preferably a version of the shape memory alloy wire described in connection with the first aspect of the invention. It is preferred that the shape memory alloy, which is activated by heating to shrink, is a single coiled spring. When activated, the spring is designed to draw the moveable means away from the open end of the second member, so that the moveable means no longer maintains the second member in contact with the first member. In order for this to occur, the heat activatable material should contract sufficiently to overcome the opposite force supplied by the spring or other bias means, which urges the moveable means towards the open end of the second member.

In connection with this embodiment, the spare tyre/wheel is fastened to the vehicle by manual insertion of the first member through the central aperture of the spare tyre/wheel and rotating it over the second member until the screw engagement is completed. The ratchet prevents unscrewing. The spring biases the moveable member towards the spare tyre/wheel to maintain the screw engagement between the first and second members. If it is desired to release the spare tyre/wheel, an operator, such as the driver, causes activation of the contractible means within the moveable means, for example, by generating a signal from the vehicle dashboard or from a key fob, causing heating of the shape memory alloy to take place. Heating may be carried out by any suitable means, for example, by resistive heating. Once the shape memory alloy spring has been heated past its transition temperature, it reverts to a memorised configuration in which the spring is contracted, overcoming the bias by the first-mentioned spring and drawing the locking means away from the spare tyre/wheel. At this stage, the drawing means draws

the second member out of engagement with the first member and the first member is released. The first member can then be withdrawn from the central aperture of the spare tyre/wheel. The wheel is then removed from engagement with the vehicle.

It is preferred that the second member is made in two or more segments, either for the whole of its length or in the region of the engaging surfaces, to enable inward movement of the received portion of the second member with the assistance of the drawing means.

It will also be appreciated that the locking system of this second aspect of the invention can be used in applications other than attachment of a spare tyre/wheel to a vehicle.

In a third aspect, the invention provides a releasable fastening system for fastening a first element to a second element, the system including:

(a) a fastening element having a flexible beam and an engagement means;

(b) actuating means attached to the fastening element and including a material adapted to contract when activated, the beam being movable, upon contraction of the material, between an engagement position and a disengagement position; and

(c) means for engagement by the engagement means and forming part of or attached to the first element.

The first element is preferably a door or flap, such as a fuel filler flap on a motor car. In this context, the second element is the body of the motor vehicle. Obviously, the scope of the invention is not limited to this application.

The fastener may be made of any suitable material, including plastic or metal. The fastener may be made of a combination of materials.

The flexible beam should have flexural modulus which is sufficiently low to enable the actuating means to move the beam in the desired manner. However, the tensile strength

of the beam should be sufficiently high that the fastener can fasten useful loads. Preferably, the material of the beam has sufficient fatigue strength to accommodate the desired number of locked/unlocked cycles.

When the beam is made of metal, this is preferably spring steel, a beryllium-copper alloy or a titanium-copper alloy. The beam may be machined, cast, moulded or formed in any desirable way. For example, the beam can be made of braided flexible cable.

The engagement means preferably takes the form of a projecting wedge which can key into a corresponding recess in a wall of an element. Other configurations are possible. For example, the engagement means may be a snap means, a rod for latching over a hook, or an aperture which can latch over a projection such as a peg. The engagement means may take the form of a dovetail on the beam fitting into an appropriate recess. The fastener of the invention can engage with an identical fastener, for example.

Preferably, the material, which contracts when activated, is a shape memory material as has been discussed above. Preferably, the shape memory material is a titanium-nickel wire which, when sufficient energy in the form of an electrical current is applied, heats to or above a temperature at which the material shrinks by about 4 to 5%. On application of energy such as electrical energy in order to generate heat above a predetermined level, the flexible beam can be caused to bend away from the engagement position in which a first element is fastened to a second element, thereby releasing the elements. Conversely, if the shape memory material is permitted to cool below the transitional temperature, in some embodiments the beam may assume the engagement position and the elements may be fastened again.

The means for engagement by the engagement means may take any suitable form. Some have already been mentioned above, for example part of a snap means, a hook, a peg, a recess or an identical fastener. Where the fastening system is used for fastening a fuel filler door to a car body, it is preferred that the means for engagement by the engagement means is an aperture on the door.

The actuating means is preferably actuated either through a suitable switch located on dash board of the vehicle or through the a signal generated from the vehicle key. The latter can be convenient because the driver does not need to remember to actuate the fuel filler door before getting out of the vehicle: the driver needs only to take the vehicle key to the fuel pump and release the fuel filler door while standing next to the vehicle.

In a fourth aspect, this invention provides a releaseable fastening system for fastening a first element to a second element, the system including:

(a) a locking pin moveable between a locked position in which the first element is secured to the second element and release position in which the first element is released from the second element;

(b) first bias means urging the locking pin to the locked position; and

(c) second bias means for urging the locking pin to the release position;

the second bias means comprising or containing material adapted to contract when activated.

The fastening system of this fourth aspect of the invention is particularly suitable for securing a roof-rack to the roof of a vehicle and/or for securing items to a roof-rack. In one example, the first element is the roof-rack while the second element is the roof of the vehicle. In a second example, the first element is an item to be secured and the second element is the roof-rack.

The locking pin may be made of any suitable material, including metal or polymeric material.

The first bias means is preferably a coiled spring. The second bias means is preferably a coiled spring made of shape memory alloy, which has been described above. Preferably, the shape memory alloy contracts when heated above its transition temperature. Heating is preferably provided by connection via a CAN or LIN to an energy source, such as the battery of the vehicle. It is also within the scope of the

invention that the energy can be applied remotely, for example, by use of an infra red beam or ultrasound and this applies to the other aspects of the fastener system of the invention as well.

It will be appreciated that the fastening system of this fourth aspect is biased towards the locked position. The system may be designed so that, upon insertion of a roof-rack into a channel or gutter on the roof of the vehicle, the fastening system locks the roof-rack automatically and requires activation of the second biased means to release it. The same description can be applied to automatic locking of items such as skis or a ladder, for example, to a roof-rack.

It is within the scope of the invention that the fastening system of this fourth aspect is employed for both securing the roof-rack to the roof of the vehicle and for securing items to the roof-rack. The respective fastening systems may be part of the CAN or LIN network, being separately addressable for activation.

In a fifth aspect, this invention provides a releaseable fastening system including:

(a) a two part bolt having an outer part and an inner part insertable in the outer part, the inner bolt part having a head at one end and an inner bolt engagement means at the other, the outer bolt part having an outer bolt engagement means;

(b) a cavity for reception of the two part bolt, the cavity including first means for engaging the inner bolt engagement means and second means for engaging the outer bolt engagement means;

(c) locking means associated with the cavity for locking the two part bolt, the locking means including a material adapted to contract when activated to release the two part bolt; and

(d) torque means, moveable to at least partially release the second means for engaging the outer bolt engagement means, including material adapted to contract when activated.

Like the second aspect of the invention, the fastening system of the fifth aspect can be suitable for fastening a spare wheel to the body of the vehicle.

The inner bolt part has a head which may take any suitable shape but which may resemble, for example, a square shaft with a convex button head. The inner bolt engagement means is preferably an enlarged portion of the bolt shaft. The enlarged portion is preferably polygonal, more preferably having between six and twelve sides.

The engagement means on the outer bolt part is preferably a screw thread.

The cavity for receipt of the two part bolt preferably has a section shaped to complement the enlarged portion of the inner bolt part - for example, a cavity having between six and twelve sides. For engagement with the outer bolt engagement means, the cavity preferably has a complementary screw thread.

The locking means is preferably a pair of lugs, biased by means of a spring or similar, towards engagement with a groove or cutaway portion on the bolt, preferably on the outer bolt part. Connected to each lug is a shape memory alloy spring which contracts when heated above its transition temperature to draw the lug out of engagement with the two part bolt. One lug is preferably opposite the other. The invention is not limited to the use of two such locking means. There may be one or more than two locking means.

The torque means preferably takes the form of two coaxial drums, one of which is fixed and the other able to rotate, the drums being placed so that there is little or no gap between them. In this embodiment, shape memory alloy wire is coiled around the outer surface of the first, fixed drum and crosses over to the second, rotatable drum, where it terminates. A second shape memory alloy wire is coiled in the opposite direction to that of the first shape memory alloy wire, around the outside of the second drum, crossing over to the first drum where it terminates. When the first shape memory alloy wire is heated above its transition temperature, it contracts and, by reason of its attachment to the second drum, causes the second drum to rotate in one direction. After the first shape memory alloy wire has cooled so that it relaxes to its previous configuration, if the

second shape memory alloy wire is heated above its transition temperature, it contracts and, by reason of its connection to the fixed drum, will cause the second drum to rotate in the opposite direction to the first direction.

It will be readily appreciated that this permits large amounts of torque to be generated between the two drums, the degree of torque increasing with increasing radius. The degree of rotation can be influenced by the number of coils of wire around the drums.

The torque means described represent an embodiment of a sixth aspect of the invention, which accordingly provides a torque means having a fixed body and a rotatable body, first material adapted to contract when activated wound around the fixed body and attached to the rotatable body, and second material adapted to contract when activated wound around the rotatable body and attached to the fixed body.

As set out above, it is preferred that the first and second material adapted to contract when activated is made of shape memory alloy wire. Other materials may also be suitable.

When the torque means is incorporated in the fastening system of the fifth aspect of the invention, activation of the appropriate shape memory alloy wire causes the rotatable body to rotate, for example, through 180°. The purpose of this is to partially release the outer bolt engagement means. Thus, when the outer bolt engagement means is a screw thread received in a complementary screw thread in the cavity, the cavity being in the rotatable body and the two part bolt being fixed by the inner bolt engagement means in the non-rotatable body, rotation of the rotatable body in the appropriate direction at least partially unscrews the bolt and relieves torque. When the locking means are released, the two part bolt can be manually removed.

It will be appreciated by one skilled in the art that the fasteners, in the various aspects of the invention, can have widespread applications. Some can be designed to be activated only by authorised parties, such as those engaged in vehicle assembly or servicing. Others can be designed to be operated by vehicle owners.

In appropriate forms, any of the fastening systems of the invention can have primary and secondary functions, the primary function being to attach components to the vehicle body and the secondary function being the control of component switching. It is possible that use of fastening systems according to the invention may reduce the number of sub-network wiring components required in a vehicle, through direct connection into the CAN bus, for example. In effect, each fastener may become its own multiplex module/communications gateway or node on the CAN bus.

The invention will now be described in connection with the following non-limiting description of certain preferred embodiments, as shown in the drawings. In the drawings:

Figure 1 is a plan view, transparent as to some detail, of a fastening system according to the first aspect of the invention;

Figure 2 is a side elevation of the embodiment in Figure 1;

Figure 3 is an end elevation of the embodiment in Figure 1;

Figure 4 is a partial perspective view of an application of the fastening system of Figures 1 to 3;

Figure 5 is a perspective view of a second embodiment of a fastening system according to the first aspect of the invention;

Figure 6 is a side elevation (sectional view) of an embodiment of the second aspect of the invention;

Figure 7 is a perspective view of an embodiment of the invention in the third aspect;

Figure 8 shows an application of the embodiment in Figure 7;

Figure 9 is a side elevation, partly in section, of the invention in its fourth aspect;

Figure 10 is a cross-sectional view of an embodiment of the invention in its fifth aspect;

Figure 11 is a perspective view of the fastening system of Figure 10, partly exploded;

Figures 12 and 13 illustrate an embodiment of the sixth aspect of the invention;

Figure 14 shows an example of how the fastening systems of the invention may be integrated into a typical vehicle CAN network, in relation to a car door;

Figure 15 is a diagrammatic illustration of at least part of the system in Figure 14;

Figure 16 shows how the network concept exemplified in Figures 14 and 15 may be extended throughout many vehicle components;

Figure 17 is similar to Figure 15 but gives an example of the extension of the function of fastener assemblies of the invention; and

Figure 18 exemplifies architecture of a fastening system of the invention in a motor vehicle.

Turning first to Figures 1 to 3, fastener 10 has a pin 12 adapted to be received in aperture 14. Latch 16 locks pin 12 by entering groove 18. Latch 16 is connected to shape memory alloy wire 20 which passes from anchor point 22 over guide 24 to end 26 of latch 16. When shape memory alloy wire 20 is heated sufficiently, it contracts, drawing on end 26 of latch 16 and hence drawing latch 16 out of engagement in groove 18, unlocking pin 12.

Pin 12 has first taper 28 and second taper 30. Second taper 30 expands to form flange 32. In Figures 2 and 3 it can be seen that flange 32 is attached to element 34. Pin 12 may of course be integral with element 34.

In Figure 4, element 34 represents the inner lining of a car door with pin 12 on the hidden side of the lining. Apertures 14 are shown on the car door body 36. To assemble lining 34 to car door body 36, pin 12 is pushed through aperture 14. Latch 16 may be designed to clip automatically into place in groove 18 or may be selectively activated to this position. To disassemble lining 34 from car door body 36, shape memory alloy wire 20 is heated sufficiently, for example by power generated to resistors (not shown) or other suitable heating means, from the vehicle computer or a hand-held device such as a personal digital assistant. Contraction of shape memory alloy wire 20 draws latch 16 out of engagement with groove 14, freeing lining 34 from car door body 36 at that point. If desired, where there are several fastening systems such as on lining 34, the fastening systems may be caused to release in a pre-determined sequence.

With reference now to Figure 5, pin 38 is designed to pass through aperture 14. Pin 38 is bisected to form a cavity 40, having at its base a channel 42 which is twisted as shown in dotted outline. Aperture 14 is contained within washer 44. Shape memory alloy wire 20 extends across the diameter of aperture 14. When pin 38 is inserted as far as possible into aperture 14, wire 20 is in the relaxed state (as shown in dotted outline) and deforms to follow the twist in channel 42, holding pin 38 within aperture 14 with the assistance of undercuts 43. When heat is applied via cable 46 to wire 20, it contracts as shown in the solid outline in Figure 5. When wire 20 contracts and straightens, it ejects pin 38 out of aperture 14. Ejection is assisted by compression spring 48 on pin 38.

Washer 44 is provided with four clips 49 so that washer 44 may be mounted in a suitable aperture, clips 49 being resilient and able to secure washer 44 within the aperture (not shown).

Turning now to Figure 6, fastening system 50 has as first member shaft 52 and as second member shaft 54. Locking means 56 is moveable within shaft 54. Shaft 52 has internal threads 58, adapted to engage external threads 60 on shaft 54.

Although not shown in Figure 6, shaft 54 is not continuous around its circumference in the region of external threads 60, but is provided in segments. When the segments of

shaft 54 are in the outward position shown in Figure 6, there are spaces between the segments so that when they are permitted to spring inwardly (when locking means 56 no longer presses them outwardly), the segments form a cylinder with a significantly smaller circumference than that of shaft 52.

In Figure 6,wheel hub 62 is shown locked to hub support 64 by fastening system 50. (The remainder of the spare wheel to which hub 62 belongs is not shown.). Shaft 52 is attached to decorative bolt head 66. As can be seen in Figure 6, shaft 52 fits over shaft 54.

Moveable means 56 includes a spring (not shown) urging moveable means 56 upwardly in Figure 6.

When shaft 52 is manually inserted through central aperture 68 of hub 62 and screwed on to shaft 54, the spring (not shown) within moveable means 56 urges moveable means 56 upwardly so that shoulder 78 maintains internal thread 58 in contact with external thread 60. The spring (which is not shown) may achieve this by bearing against floor 72 and against ceiling 74 of moveable means 56. Bolt head 66 cannot be loosened by unscrewing because of one-way ratchet or pawl 71.

To disengage fastening system 50, a radio frequency signal - for example, from the driver's key, having a push button for this purpose - activates heating means (not shown) connected to shape memory alloy spring 76 causes spring 76 to contract. Spring 76 is anchored between floor 72 and ceiling 74 and therefore contraction of spring 76 draws ceiling 74 towards floor 72, in this way lowering moveable means 56. When moveable means 56 lowers, shoulder 78 is taken out of engagement with shaft 54. As moveable means 56 is drawn downwards, flange 73 gathers up ends 75 of segments of shaft 54 and pulls external thread 60 out of engagement with internal thread 58. Shaft 52 can then be withdrawn without rotation, via decorative bolt head 66, from aperture 68 and hub 62 of the spare wheel is released.

Reference is now made to Figures 7 and 8. Figure 7 shows in perspective view an embodiment of the third aspect of the invention, while Figure 8 shows an application of that embodiment. Fastening system 80 has fastening element 82 which includes flexible beam 84. Flexible beam 84 is attached to a second element, in this case being the body of a motor vehicle (not shown). Flexible beam 84 also includes at its base cavity 83 which accommodates electronic components (not shown). At the end of flexible beam 84 remote from cavity 83 are engagement means 86, taking the form of a projecting wedge.

Actuating means 88, being a shape memory alloy wire, are attached to flexible beam 84 behind engagement means 86 and form a loop from engagement means 86, passing through lug 89. In Figure 7, wire 88 is shown in the contracted form after heat has been applied. In this configuration, wire 88 has drawn back engagement means 86 from engagement in recess 90. Recess 90 is secured to a first element, in this case being the flap or door of a fuel filler in a motor vehicle.

Once shape memory alloy wire 86 is permitted to relax, it can again engage recess 90, for example when flap 92 is to be closed.

Flap 92 and recess 90 are shown in Figure 8 in relation to fuel filler closure 94.

Figure 9 shows an embodiment of the fourth aspect of the invention. In Figure 9, fastening system 96 includes locking pin 98 having head 99 and base 97. Locking pin 98 is contained within channel 102 located on the roof of a vehicle (not shown).

The first element 100, in this embodiment part of a roof rack, includes cavity 101. When roof rack 100 is manoeuvred into position in roof channel 102, spring 104 urges head 99 of locking pin 98 into cavity 101, locking roof rack 100 into place.

To release roof rack 100, heat is generated in a suitable manner in shape memory alloy spring 106, which accordingly contracts after being heated to or above its transition temperature, drawing back base 97 of locking pin 98 until head 99 is clear of cavity 101.

Although not shown, elements on roof rack 100 may be secured and released in a similar manner. Such elements may comprise, for example, holders for ski racks or a ladder.

Reference is now made to the invention in the fifth aspect, shown in Figures 10 and 11. In this embodiment, releasable fastening system 108 has a two-part bolt 110. Outer bolt part 112 has an external screw thread 114 and a knurled head 116. Inner bolt part 118 has square shaft 120 having at one end button head 119 and at the other bolt engagement means 124. As illustrated, bolt engagement means 124 has twelve sides. The number of sides may be varied.

Two part bolt 110 is shown in Figure 10 received in cavity 126 of car body 128. Cavity 126 has first means for engaging inner bolt engagement means 124, namely a complementary 12-sided shape to portion of cavity 126 at 130. Obviously, the shape of the cavity at 130 should be changed according to the shape of bolt engaging means 124. Cavity 126 also includes second means for engaging the outer bolt engagement means. In Figure 9 these second means are an internal screw thread 132.

Associated with cavity 126 are locking means having lugs 134, biased towards cavity 126, and shape memory alloy springs 136. When activated, springs 136 contract to draw lugs 134 out of contact with two-part bolt 110. Until that occurs, bolt 110 is trapped within car body 128.

Fastening system 108 also includes torque means. As can be seen in Figure 11 and as per the principle described in connection with Figures 12 and 13 (see below), the torque means includes coaxial fixed drums 138 and 140. Around drum 140 is rotatable spindle 148. Shape memory alloy wire 142 and 144 is wound around drum 138 and through spindle 148. Further details of a similar configuration are explained in connection with Figures 11 and 12, below. When shape memory alloy wire 142 is activated, it will cause spindle 148 to rotate in one direction, relieving tension on bolt 110 and permitting unscrewing and withdrawal of bolt 110 from fastening system 108 (provided lugs 134 have been pulled clear of cavity 126). If smart memory alloy wire 144 is activated,

spindle 148 rotates in the opposite direction, increasing tension on bolt 110 and providing secure fastening of wheel hub 62 to car body 128. Slide 146 maintains pressure on outer bolt part 112 when spindle 148 rotates.

An embodiment of the principle of the sixth aspect of the invention is shown in Figures 12 and 13. As will be seen from these Figures, drum 138 is fixed and drum 140, coaxial with drum 138, is rotatable (in contrast to Figure 11). Shape memory alloy wire 142 is attached at terminal A on drum 138 and wound around drum 138, crossing over to drum 140 to end at terminal B. Shape memory alloy wire 144 is coiled in a reverse direction to that of wire 142 and commences from terminal C on drum 140 to terminate at terminal D (not shown) on drum 138.

When sufficient heat is applied to wire 142, it contracts, drawing its attachment at terminal B on drum 140 towards the position shown in Figure 13, rotation being in the direction of arrow 150. The amount of rotation depends on the number of coils around the drum.

It will be appreciated that the illustrations in Figures 12 and 13 are not drawn on a scale suitable to fit in Figure 11.

Figure 14 is an example of integration of the fastening systems of the invention in a typical vehicle CAN network, specifically showing a car door. This illustration is largely self-explanatory. Some of the fasteners of the invention are referred to in Figure 14 as part of the "Intelligent Fastener network". These perform the primary functions of the fastener of the invention, namely to attach components within the vehicle.

Other fasteners referred to in Figure 14 as "Fastener nodes" are performing a secondary function, namely control of the relevant component, such as the window motor, the rear vision mirror, etc.. Connection to the CAN bus is also shown.

Shown in enlarged form at 152 is a fastener similar to fastener 80 in Figure 7.

It is to be appreciated that the component layout and wiring harness in Figure 14 is merely an example and not limiting on the scope of the invention.

Figure 15 is a diagrammatic illustration of part of the system in Figure 14. Some of the fasteners of the invention, referred to as "TZ Intelligent Fasteners" are carrying out the primary function discussed above and some are carrying out the secondary function.

The primary and secondary functions referred to can be expanded to control or fasten several other vehicle components, such as those shown in Figure 16. This Figure is self-explanatory.

Figure 17 shows how the fasteners of the invention may be arranged to reduce the number of sub-network wiring components through direct connection into the CAN bus. Figure 17 should be compared with Figure 15 in this regard. In effect, each fastener of the invention may be able to act as its own multiplex module/communications gateway or node on the CAN bus. This network structure may also enable the fasteners of the invention to extend their function into control of components switching.

With reference to Figure 18, this illustrates an example of the architecture of a fastening system of the invention in a motor vehicle. At the bottom of the chain is a fastener of the invention, which fastens a component to the vehicle. This fastener (the "Intelligent Fastener") is connected to the vehicle computer via the CAN bus. The vehicle computer transmits data and/or instructions between the Intelligent Fastener and an "Intelligent Tool" such as a personal digital assistant (hand-held computer).

The master control resides at the top level of the hierarchy, providing Intelligent Fastener identity and security information to the Intelligent Tool and logging diagnostic and historical fastener function information.

As before, the Intelligent Fastener may have a primary function of attaching a component to the vehicle and a secondary function of control of switching.

It is to be appreciated that many modifications and variations may be made to the embodiments described herein without departing from the spirit or scope of the invention.

Dated this 15th day of October 2003

Telezygology Inc.
By its Patent Attorneys
Chrysiliou Law

Figure 1

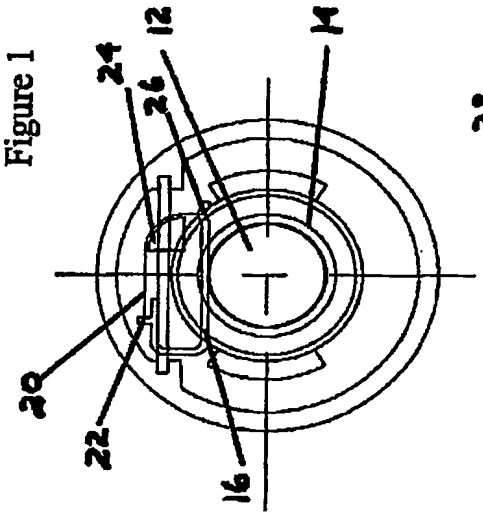
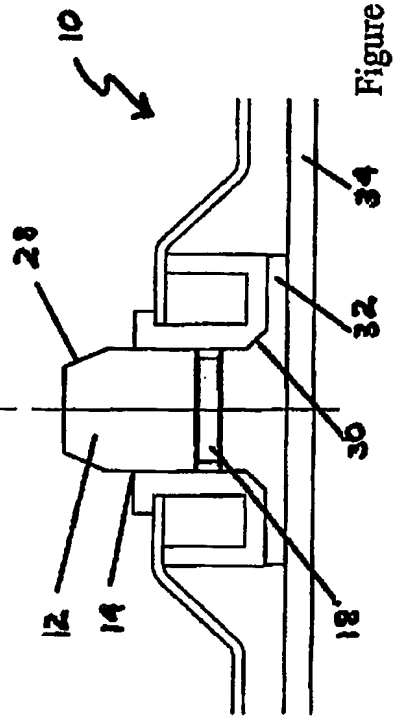


Figure 3



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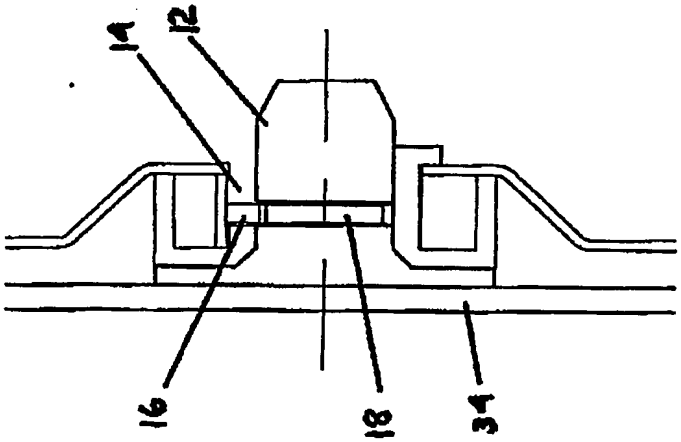

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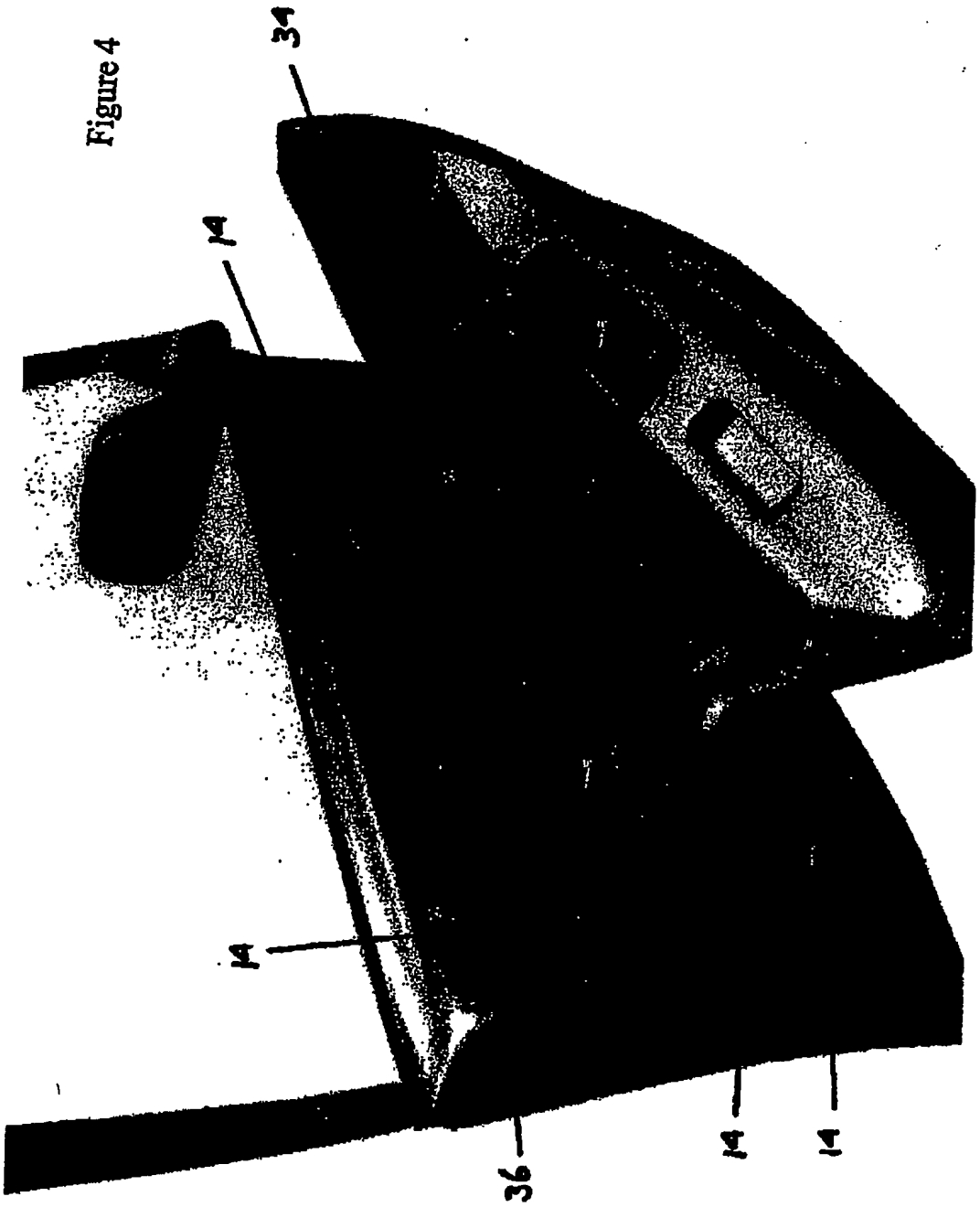

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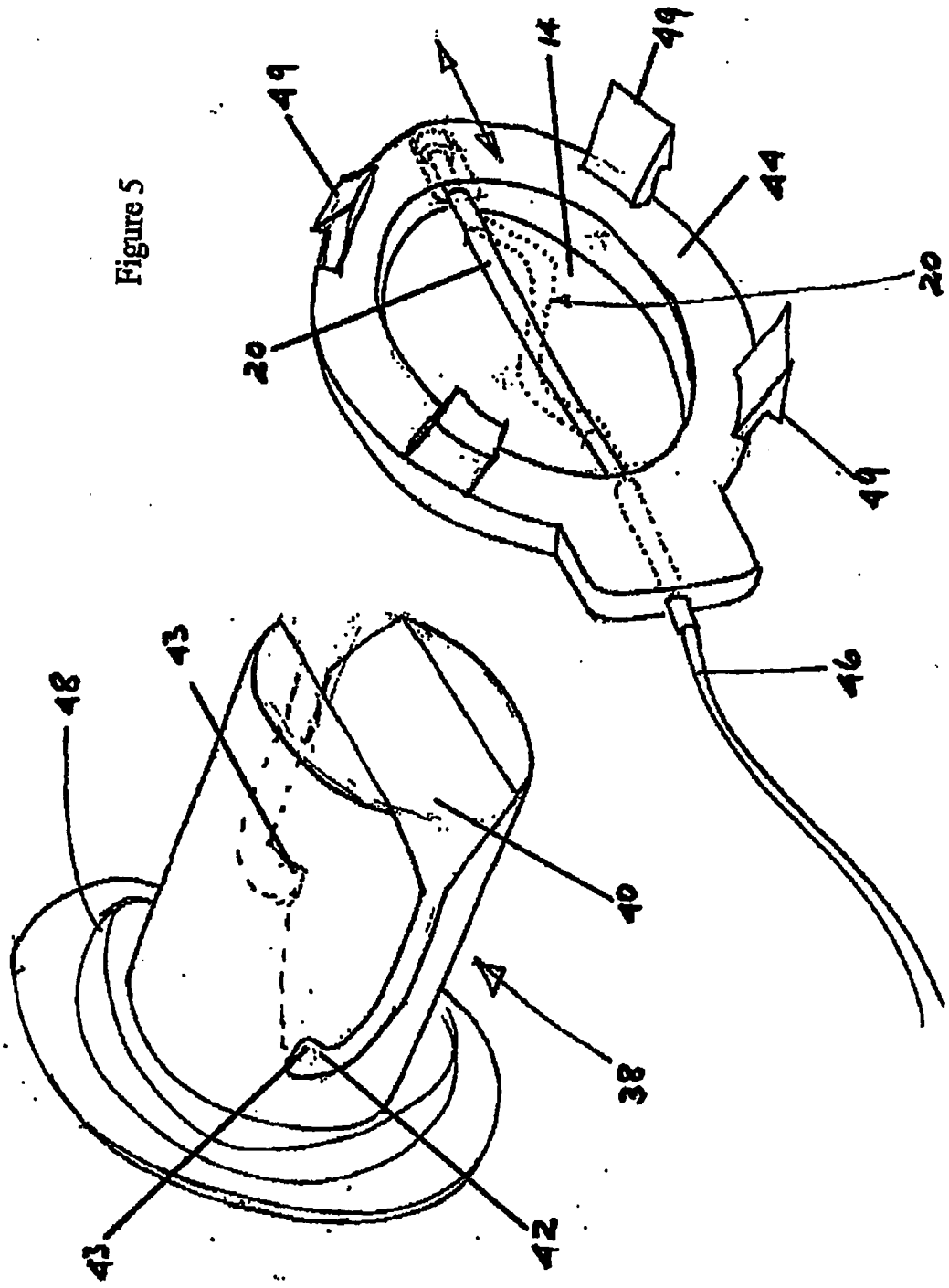

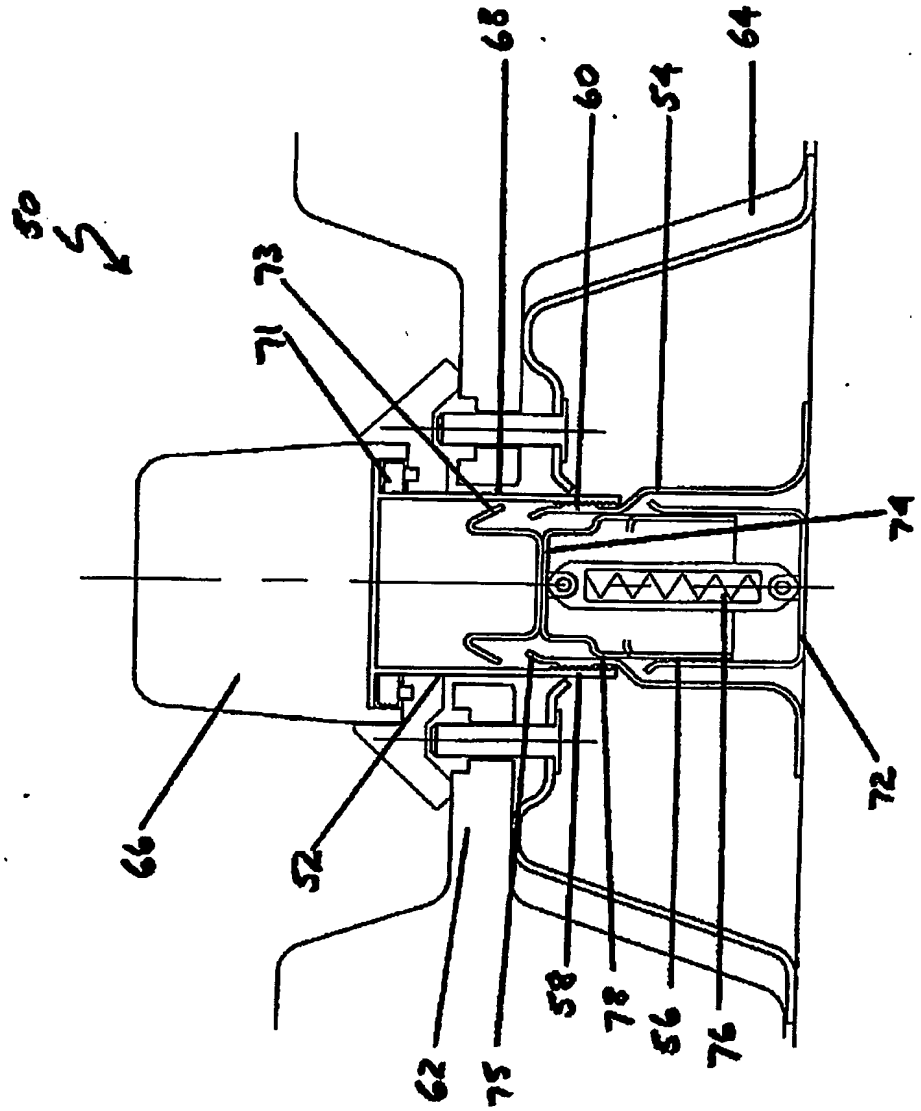

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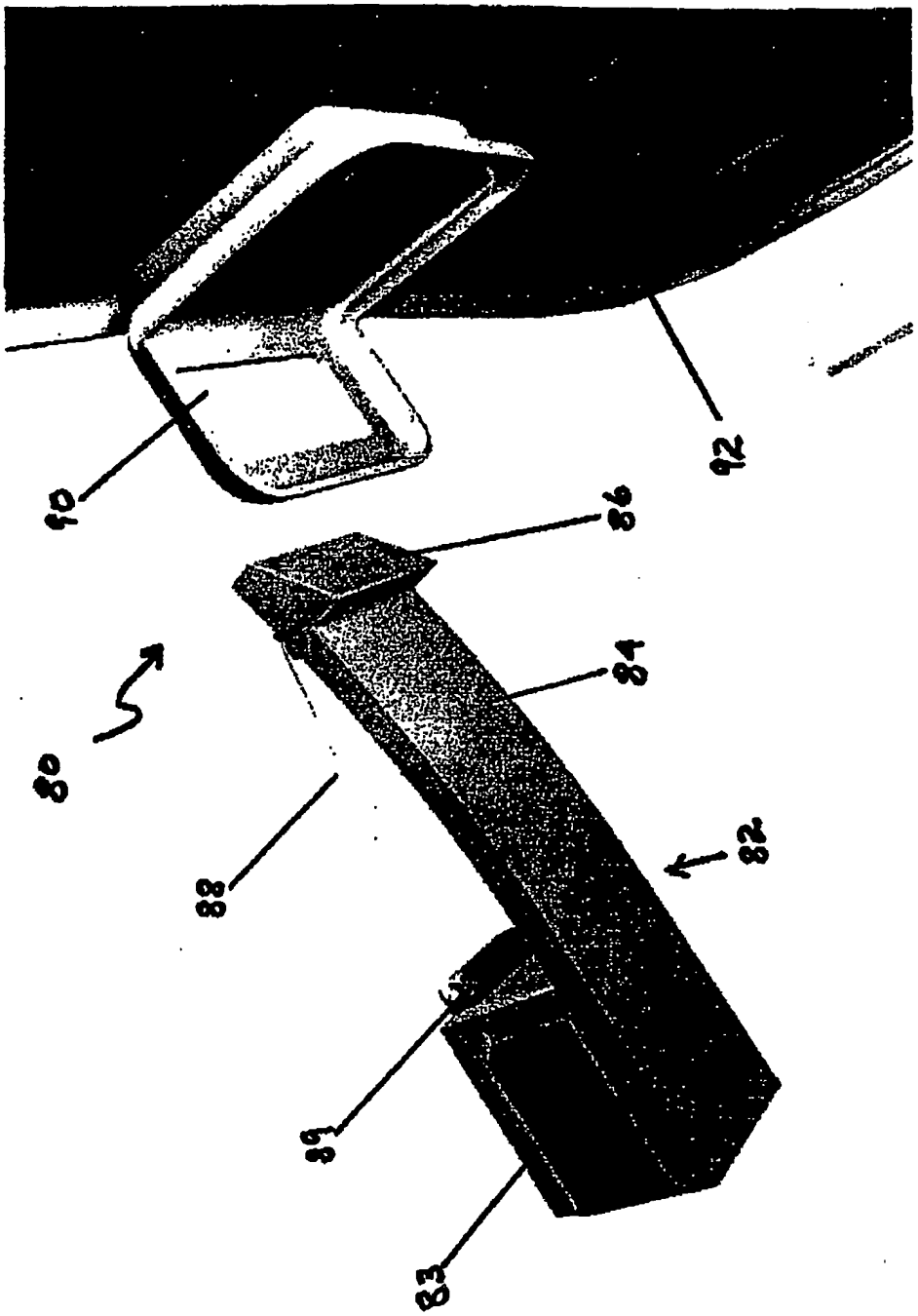

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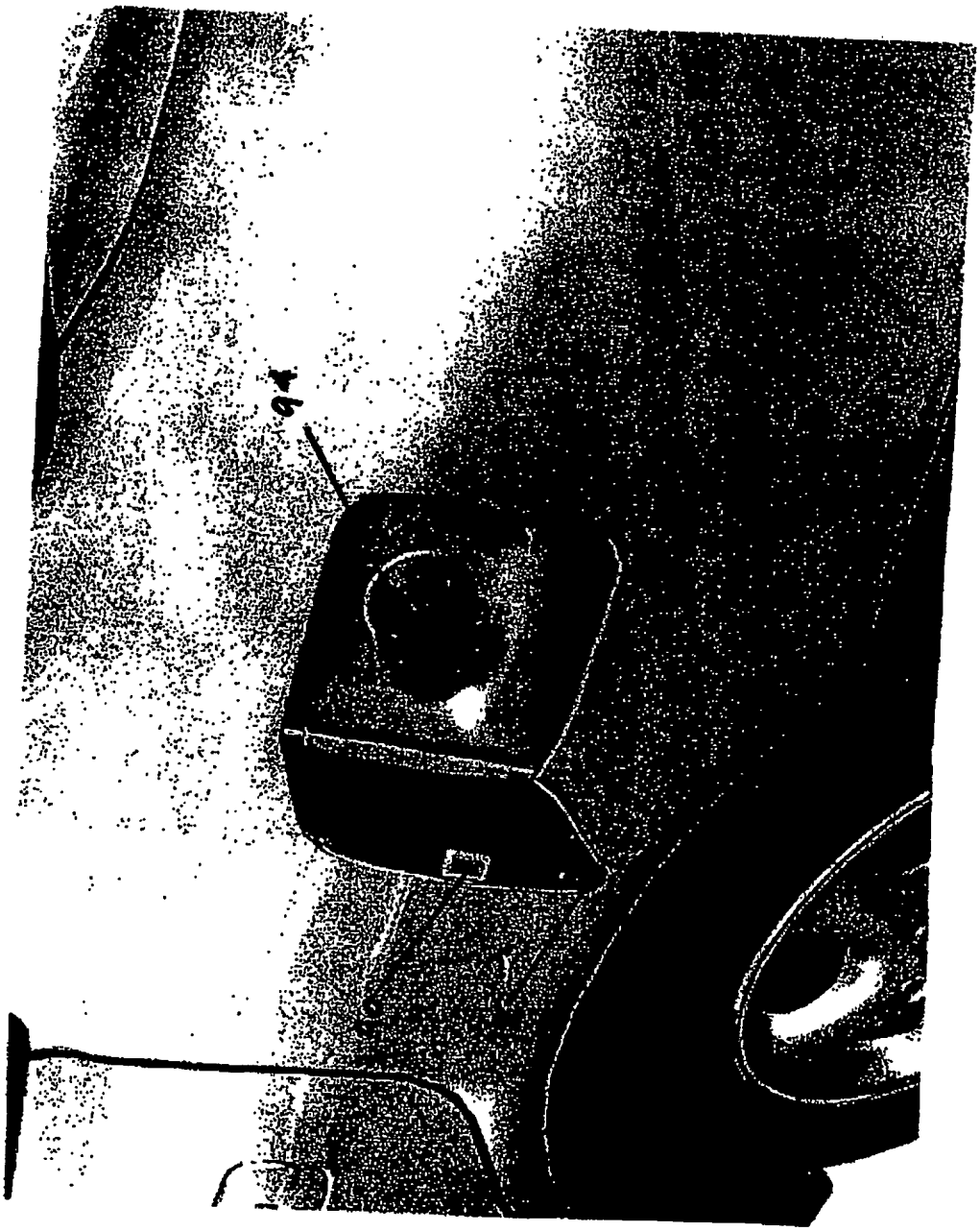

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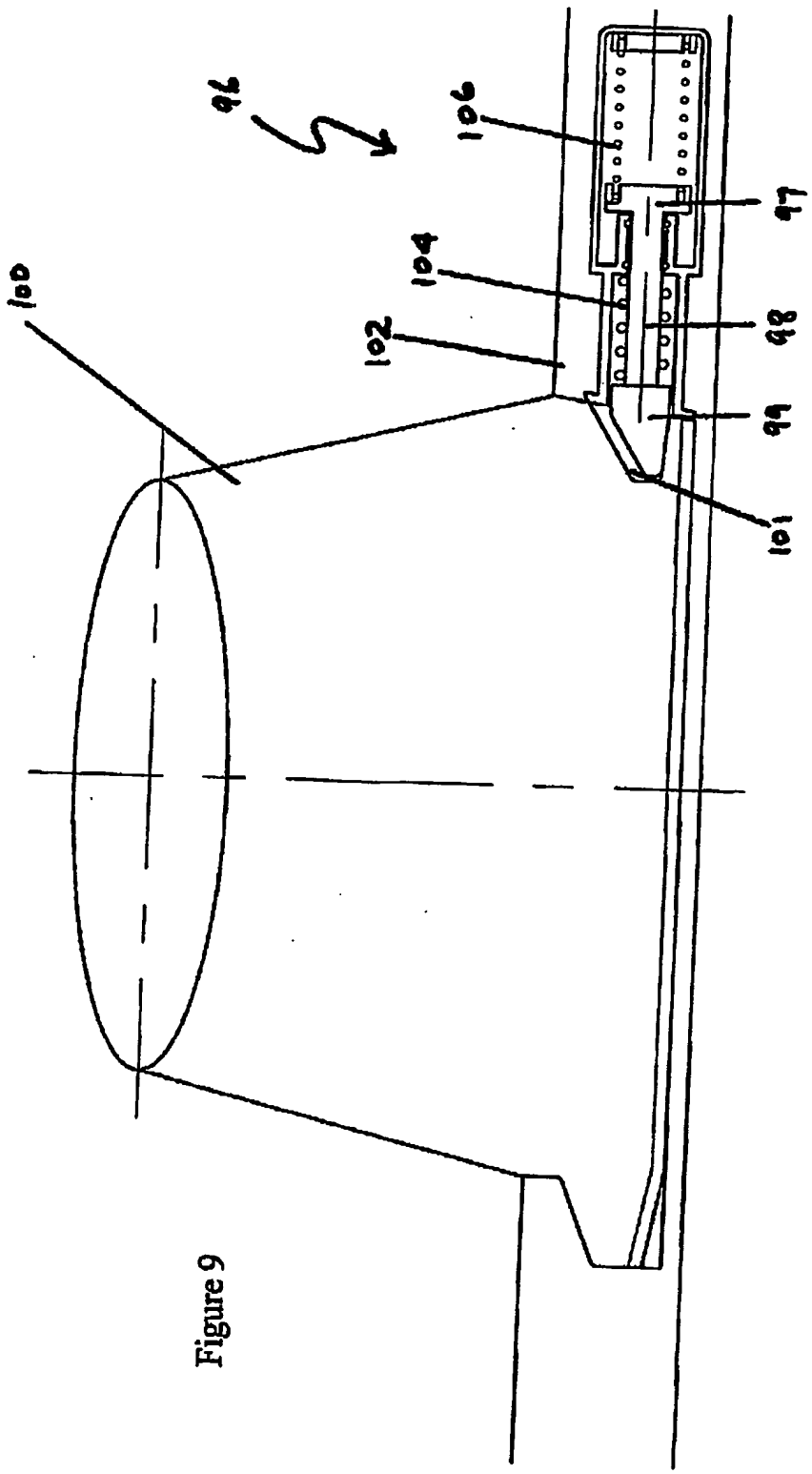

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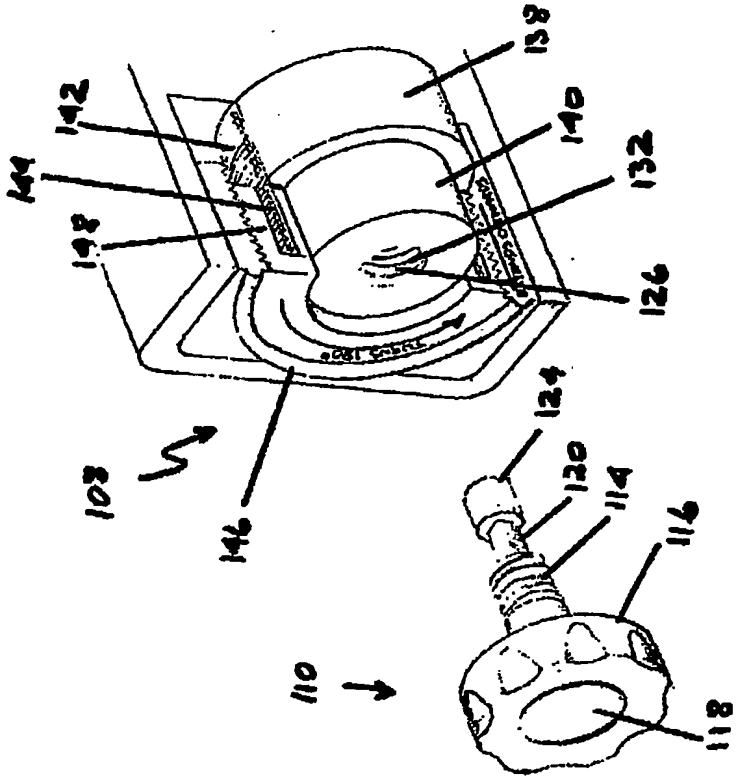

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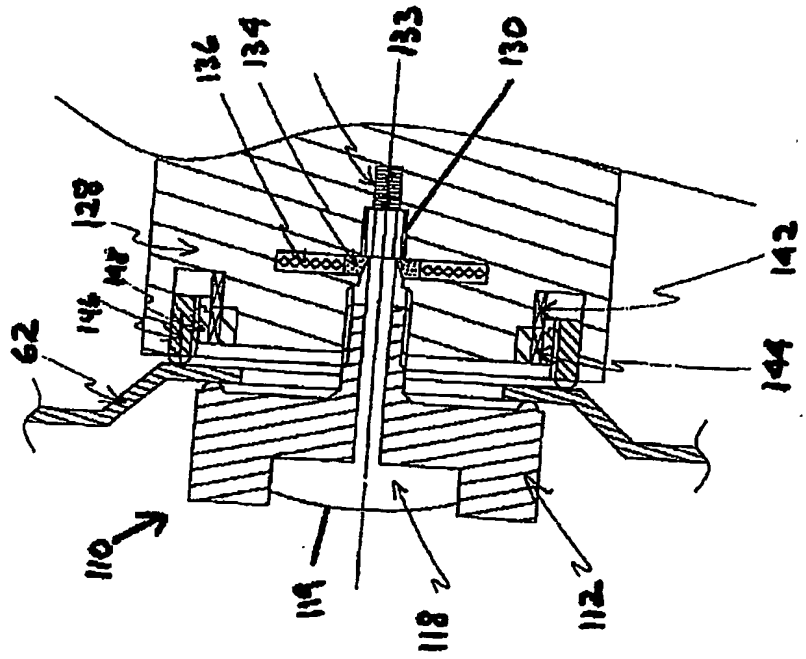
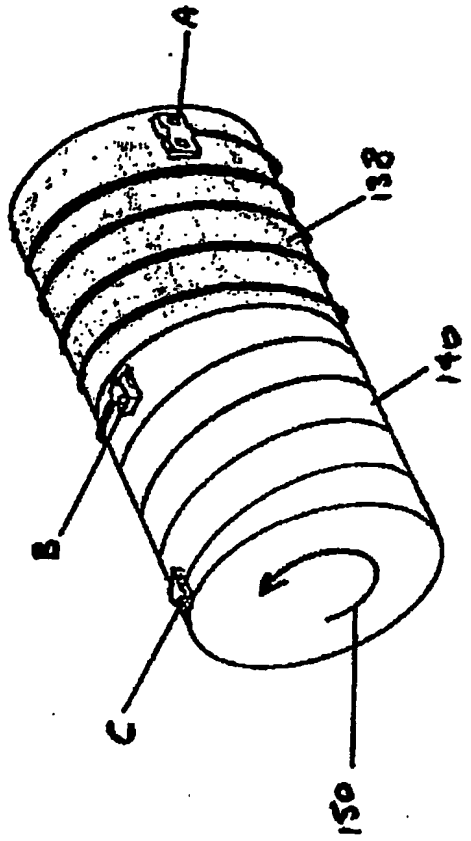


Figure 10

Figure 13



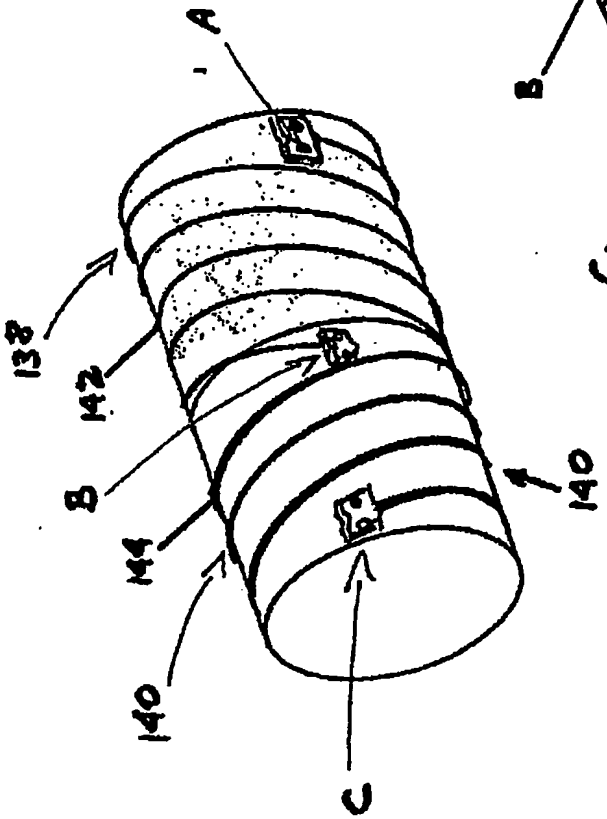


Figure 12

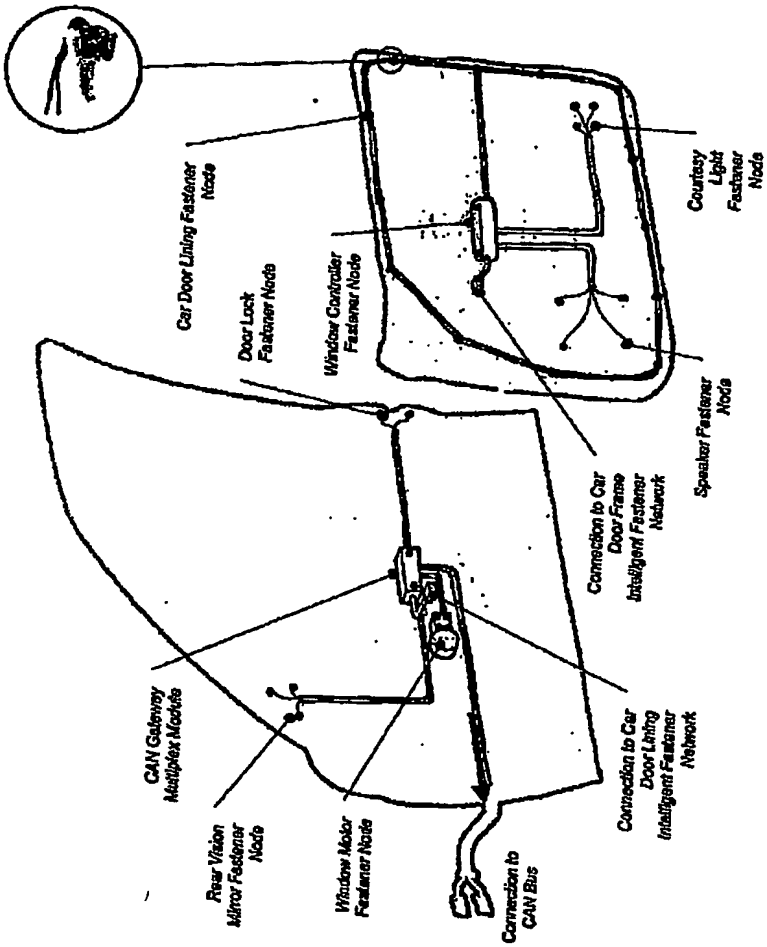

Car Door Lining Fastener Node
Door Lock Fastener Node
Window Controller Fastener Node
Courtesy Light Fastener Node
Speaker Fastener Node
Connection to Car Door Frame Intelligent Fastener Network
CAN Gateway Multiplex Module
Rear Vision Mirror Fastener Node
Window Motor Fastener Node
Connection to CAN Bus
Connection to Car Door Lining Intelligent Fastener Network

Figure 14

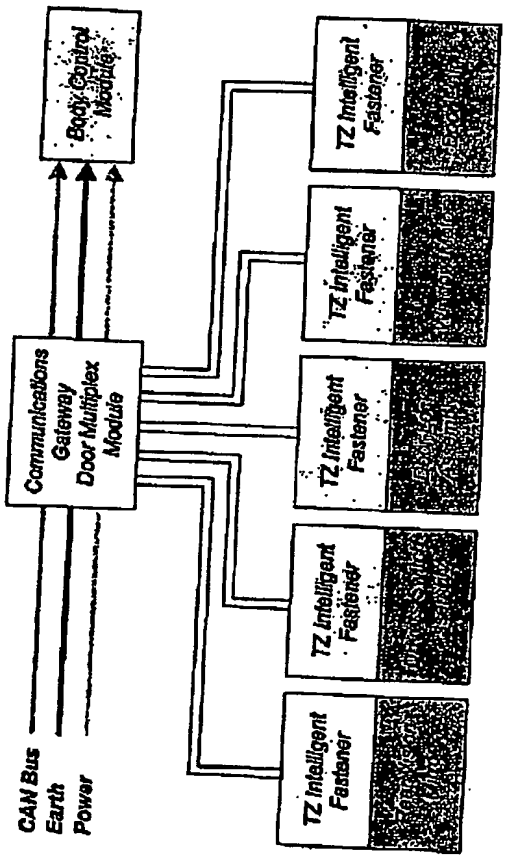

Body Control Module
Communications Gateway Door Multiplex Module
TZ Intelligent Fastener
TZ Intelligent Fastener
TZ Intelligent Fastener
TZ Intelligent Fastener
TZ Intelligent Fastener
CAN Bus
Earth
Power

Figure 15

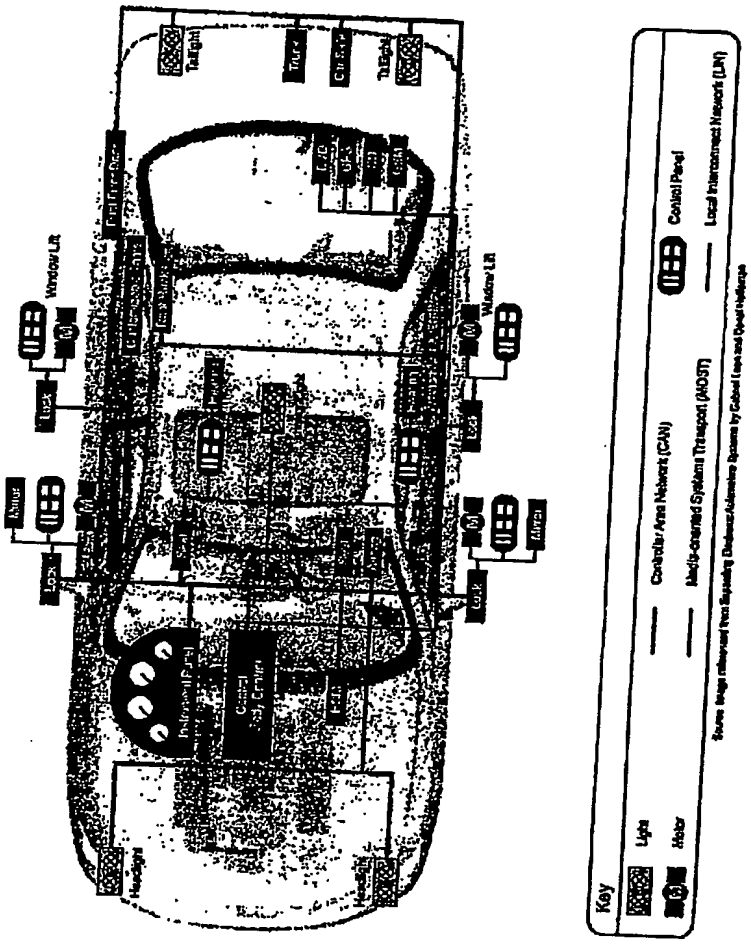

Window LR
Window LR
Key
Light
Motor
Controller Area Network (CAN)
Multi-channel Systems Transport (MOST)
Control Panel
Local Interconnect Network (LIN)

Figure 16

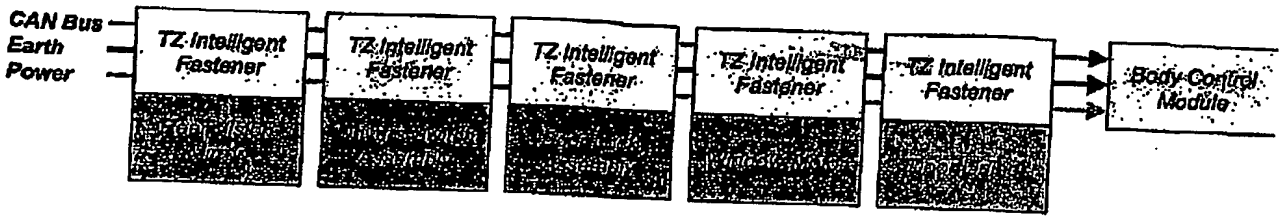


Figure 17

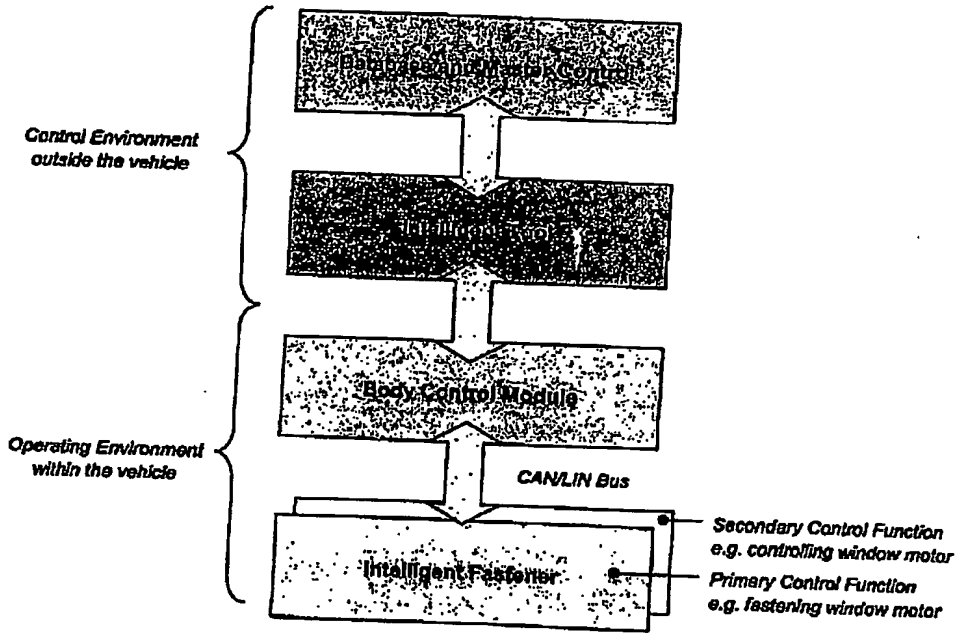


Figure 18